FEATURE

Understanding the Role of Recreational Angling Technology in Angler Expectations of Catch, Trip Catch, and Angler Satisfaction

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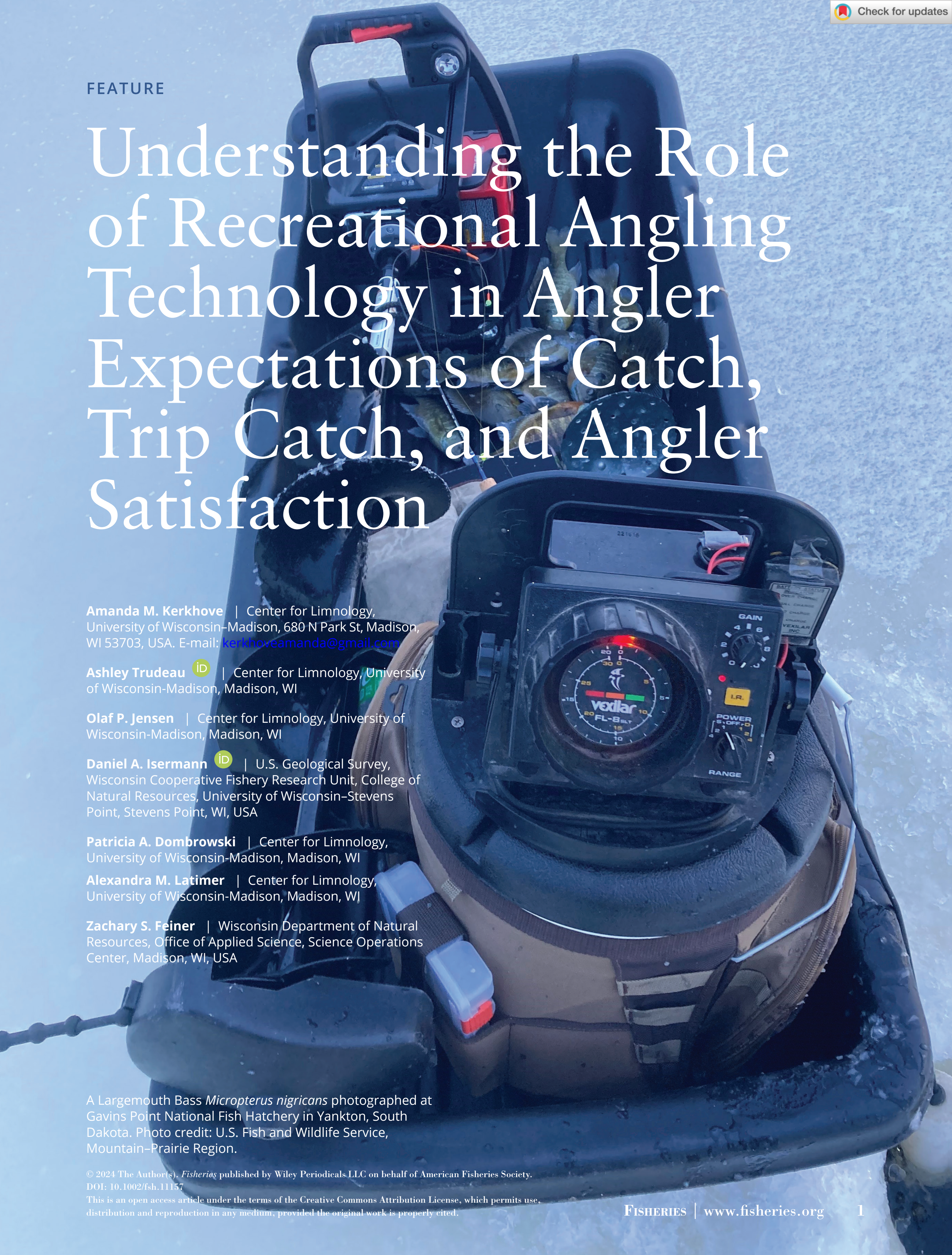

A Largemouth Bass *Micropterus nigricans* photographed at Gavins Point National Fish Hatchery in Yankton, South Dakota. Photo credit: U.S. Fish and Wildlife Service, Mountain–Prairie Region.

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Rapid technological advancement often receives a mix of criticism and welcome implementation. Fishing technologies, such as sonar, are believed to enable anglers to be more efficient and effective in their angling. There are concerns from anglers and managers of increased catch by technology users. We assessed the relationships between technology use—defined as the use of imaging technology such as sonar and underwater cameras—and catch, angler expectations of catch, and trip satisfaction using a dual intercept creel survey. Angling technologies were used by 80% and 79% of intercepted boat and ice anglers, respectively, but only 3.9% of shore anglers. Fishing technologies increased expected catch for game fish anglers, but not panfish anglers, and had no effect on actual catch for either group. Most anglers caught fewer fish than expected, and technology did not improve their ability to meet expectations. Technology use was associated with decreased overall satisfaction among panfish and game fish anglers. These results suggest that concerns about fishing technology increasing catch may not be warranted. Rather, technology use may affect angler expectations and negatively impact angler satisfaction, potentially influencing angler behavior.

INTRODUCTION

Recreational fisheries have far-reaching ecological, cultural, and socioeconomic impacts on ecosystems (Arlinghaus et al. 2012, 2013). Understanding the behaviors of angler communities is integral for the management of recreational fisheries (Hunt et al. 2013; Arlinghaus et al. 2017; Wilson et al. 2020). A rapidly transforming dynamic with the potential to influence recreational angling is an ongoing technological revolution (Feiner et al. 2020a; Birdsong et al. 2021). Technological advancements like geographic positioning systems (GPS) and electronic lake maps, side-scan or down-imaging sonar systems, or underwater cameras can be used to locate features that attract fish and enable anglers to react in real time to fish behaviors. These technologies have also been widely adopted by anglers (Feiner et al. 2020b), leading to concerns by anglers and fisheries managers about the increased potential for overharvest. However, research on the effects of technology on angler behavior and catch rates is limited. Previous studies focused on either a single fishing season (Feiner et al. 2020a) or a single species (Neely et al. 2022, 2023), limiting our ability to fully understand technology's potential effects. Of previous literature, only Neely et al. (2023) assessed how fishing technologies influenced angler attitudes and behaviors, focusing on expected catch and active fishing time. This study highlighted an important gap in our understanding of the effects of technology on recreational fishing dynamics.

The reasons anglers seek out recreational fishing opportunities range widely, but can often be categorized as those experiences related to catching fish (e.g., size or species preferences, or desires to harvest fish for consumption) or non-catch-related experiences (e.g., recreation-seeking, connection to nature; Beardmore et al. 2013; Hunt et al. 2019; Wilson et al. 2020). Motivations from non-catch-related factors have been shown to be more important to anglers' satisfaction (Arlinghaus 2006; Golden et al. 2019). For example, anglers who prefer isolation may choose to fish in more distant waters, while size and number of fish caught are less controllable by anglers (Birdsong et al. 2021).

It is important to note that angler satisfaction is not solely a product of trip outcomes, but instead likely arises as a product of previous expectations and reality (i.e., disconfirmation). The theory of expectation disconfirmation, where positive disconfirmation defines experiences where reality exceeds expectation and negative disconfirmation defines experiences where reality fails to meet expectations (Oliver 1980), has been used to understand satisfaction within a variety of recreation activities from camping to tourism and travel (Dorfman 1979; Morgan and Dong 2008). Satisfaction can be expected to increase when an outcome exceeds expectations, but decreases when outcomes fail to meet expectations. Thus, understanding factors that can influence both expectation and outcomes (e.g., angler catch) has clear potential applications to recreational fishing and angler behavior.

Technological advances in fishing have the potential to influence both expectation and outcome. Anglers using technology, which was defined for the purposes of this study as the use of imaging technology (sonar and underwater camera), may expect and achieve higher catch than non-technology users. However, measuring the effect of these technological advancements can be challenging. First, experience and angling avidity may be correlated with specialization of recreational tools, where more avid anglers use more specialized gear and tactics (Bryan 1977; Neely et al. 2023). Second, expectations are also influenced by previous experiences and motivations; therefore, anglers who have more experience fishing may have a more realistic expectation of catch (Oliver 1980; Beardmore et al. 2013). Many angler survey methods are not able to gather information about angler expectations, as they typically rely on interviewing anglers at the end of their trips (Ditton and Hunt 2001; Deroba et al. 2007), and recall bias may prevent collection of unbiased data regarding pre-trip expectations when using post-trip interviews (Blair and Burton 1987; Andrews et al. 2018). Therefore, current research on angler satisfaction lacks exploration of expectations, and whether the advancement of new technologies may influence angler expectations, outcomes, and satisfaction (Gnoth 1997; Ponte et al. 2021).

The purpose of this study was to address the current knowledge gap surrounding how angling technologies may influence both expected and actual catch, and how these factors influence trip satisfaction (Figure 1). To do this, we interviewed anglers in two Wisconsin counties before and after fishing trips to determine (1) the proportion of anglers using these technologies, (2) if angler expectations of catch and actual catch varied in relation to technology use, and (3) if the relationship between expectations and actual catch, as well as angler satisfaction, varied in relation to technology use. We initially hypothesized that technology would increase both anglers' expectations and actual catch, and that technology users would rate satisfaction higher when compared to non-technology-using anglers, as they may be more likely to meet their expectations.

METHODS

Study Area

Creel surveys were conducted at nine lakes within Dane County in southern Wisconsin and at 18 lakes in Vilas County in northern Wisconsin (Figure 2). Dane County is dominated by urban development and agriculture with a population density of 181 people/km^2. Vilas County is mostly second-growth forest with a population density of 10 people/km^2 (Carpenter et al. 2007; U.S. Census Bureau 2021). Dane County lakes are, on average, larger than those in Vilas County, which contains smaller but more densely distributed lakes. Surveys were conducted at Vilas County lakes ranging from 0.26 to 15.44 surface km^2, with a single access point on each lake. In Dane County, we surveyed anglers at 15 access points across 9 lakes, ranging from 0.05 to 39.83 km^2 in surface area (i.e., some urban county lakes had multiple access points; Figure 2).

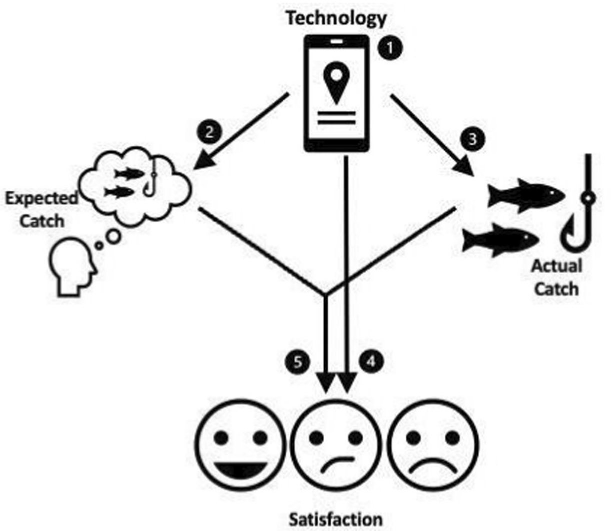

Figure 1. Diagram of expected relationships between **(1)** technology and **(2)** expected catch, **(3)** trip catch, **(4)** satisfaction, and **(5)** the relationship between expected and actual catch and satisfaction. Technology was hypothesized to increase expectations and actual catch leading to higher angler satisfaction.

Data Collection

Data were collected using a dual intercept creel survey method. This survey was conducted under protocol 2020–0972 approved by the Institutional Review Board at the University of Wisconsin–Madison. Interviews were conducted during the 2022 winter season from January 11 through March 20 in Dane County and January 11 through March 27 in Vilas County. Interviews in the 2022 summer season were conducted from May 22 through August 31 in Dane County and June 2 through August 14 in Vilas County. Creel shifts were conducted every weekend and on rotating weekdays. Four creel shifts were scheduled each week on every Saturday and Sunday in addition to two weekdays, which changed weekly ensuring that each weekday was scheduled at least once a month. Lakes in Vilas County were randomly assigned for each creel shift. In Dane County, to account for multiple access points on lakes, each creel shift was randomly assigned an access point. Every third creel shift was conducted on Lake Mendota and a random access point ($n = 5$) was selected, while all other shifts were randomly allocated among the remaining access points across the other lakes ($n = 10$). The higher frequency sampling of Lake Mendota was done for the purpose of collecting creel data for the Wisconsin Department of Natural Resources. Creel surveys took place during daylight hours during one of two possible shifts: morning shifts starting just before dawn, and evening shifts ending just after sunset. During the ice fishing season, morning shifts lasted from 0600 to 1400 hours and evening shifts from 1100 to 1900 hours. Summer season morning shifts lasted from 0530 to 1330 hours and evening shifts from 1330 to 2130 hours.

Anglers were approached twice for interviews, once before they started their trip and again after trip completion (Supplementary Figure 1). In the pre-trip interview, the number of anglers in the party was recorded and parties were asked for their target species, expected catch, and trip length. Creel clerks were instructed not to provide information to anglers regarding other angling parties to prevent expectation bias. To

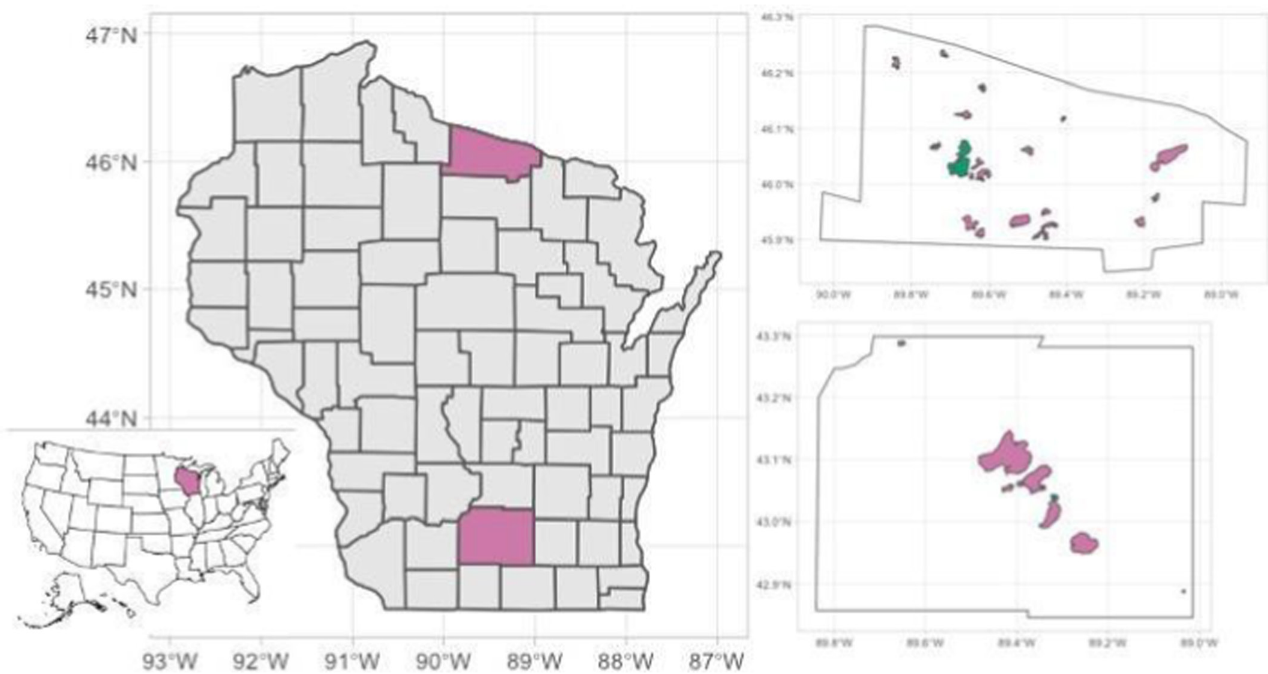

Figure 2. Map of study lakes visited only in winter (green), and lakes visited during both seasons (pink).

index intended technology use, anglers were also asked if they were planning to use electronic devices (e.g., sonar and underwater cameras) while they fished. Basic identifying information (e.g., boat type and color) was also noted so the pre- and post-trip interviews could be matched.

Post-trip interviews included questions about catch and technology type, grouped into categories (underwater cameras, sonars, GPS/chart plotter, trolling motors with spot locking capabilities, and other). To measure angler satisfaction with their fishing trip, anglers were asked two questions measured on a 10-point, Likert-style scale (Joshi et al. 2015; Subedi 2016), with 1 being "least satisfied" and 10 being "most satisfied." The questions were (1) "How satisfied were you overall with your trip today?" and (2) "How satisfied were you with the number of fish you caught today?" All data are publicly available (Jensen 2023).

Statistical Analysis

Beyond summarizing the full data set (e.g., number and location of interviews), we analyzed a subset of the data (i.e., retaining only anglers who targeted game fish and panfish), removing interviews where electronic use was not recorded, and removing interviews where catch was unrealistically high (such as "1 million Bluegill"). To estimate the effect of technology on (1) expected catch, (2) actual catch, (3) the difference between expected and actual catch, and (4) angler satisfaction. For analysis and visualization, we used lme4 (Bates et al. 2015), emmeans (Lenth et al. 2024), and tidyverse (Wickham 2016) packages in the R statistical environment, version 2.4.1 (R Core Team 2022).

Prevalence of Technology Use among Different Angler Classifications

Anglers were categorized by their fishing mode (boat, shore, or ice fishing) and their target species: "game fish," such as Largemouth Bass *Micropterus nigricans* (Page et al. 2023), Walleye *Sander vitreus*, or Northern Pike *Esox lucius*; or "panfish," such as Bluegill *Lepomis macrochirus*; Black Crappie *Pomoxis nigromaculatus*; and Yellow Perch *Perca flavescens*, based on Wisconsin Department of Natural Resources classification of fish species for harvest regulations (Supplementary Tables 1 and 2). Anglers were categorized as technology users from both pre-trip expectations of technology use (i.e., expecting to use imaging technology such as sonar or underwater cameras) and from post-trip reporting of using sonar devices (Supplementary Figure 2). We did not assess the effect of specific types of sonar technologies (i.e., technology users may have used any of the following: basic depth finders, down/side-scan imaging equipment, or forward-facing sonar equipment). Logistic regression models were fitted to the response variable of technology use and non-use to predict the prevalence of technology use among anglers fishing for panfish and game fish from boats, from shore, and on the ice. The emmeans package (Lenth et al. 2024) was used to calculate estimated marginal means of proportion of technology use among anglers and their estimates' standard errors. Differences in technology use among fishing modes by species type were determined using pairwise *t*-tests of the estimated marginal means with a Tukey adjustment for multiple comparisons with an alpha level of 0.05.

Model Selection: Expected and Actual Catch

To investigate the effect of technology on expected and actual catch (number of fish) we used the lme4 R package (Bates et al. 2015) to fit negative binomial generalized linear mixed effects models to expected and actual catch data. These models each used a log link function. All pre-trip interviews were used to calculate expected catch, and all post-trip interviews were used to calculate actual catch. Following Zuur et al. (2009), the variance structure was determined first using hypothesis-driven model selection and fitting five plausible random intercept-only models to account for non-independence of expectations and actual catch within trips, individual lakes, or within the two counties. Therefore, the random intercept models included lake, angler, angler nested within lake, angler nested within county, and county (Supplementary Tables 3 and 4). Model fits were compared using Akaike information criterion (AIC) scores with a difference of >2 indicating a better fit variance structure (Burnham et al. 2002).

Fixed effects and plausible interactions were then added to the best fitting model: fishing mode (e.g., shore, boat, or ice fishing), target species type (e.g., game fish or panfish) and the indicator of fishing technology use. In total, we fit seven plausible models for expected and actual catch (Supplementary Tables 5 and 6). Non-identifiable models (i.e., models where insufficient repeated observations were available to estimate random effects) were removed from the selection process. Final model structures for expected and actual catch were determined by lowest AIC with a ΔAIC >2 indicating a better fit (Burnham et al. 2002). The emmeans package was used to calculate estimated marginal means and standard errors (Lenth et al. 2024).

Relationship between Actual and Expected Catch

We used linear mixed models to assess the effect of technology on the relationship between expected and actual catch. To control for variation among anglers in traits like avidity or skill level when testing for the effect of technology use on the relationship between expectations and reality, we limited this analysis to paired pre- and post-trip interviews of the same fishing party. As above, we first determined variance structure by comparing models with random effects of lake, angler, angler nested within lake (Supplementary Table 7). After selecting the appropriate random effect structure, we included expected catch and technology use, species type, and their interactions as fixed effects (Supplementary Table 8). The final model structure was determined by lowest AIC (Burnham et al. 2002). Parameter effects were used to determine the significance of both expected catch and species type on trip catch. Confidence intervals for slope (i.e., the relationship between expected and actual catch) were used to determine if the relationship differed from 1 (i.e., that anglers met their expectations).

Utilizing expectancy disconfirmation theory, the difference between expected and actual catch were calculated from paired interviews (Dorfman 1979; Oliver 1980). Angler parties were categorized as experiencing "positive" (expected catch > actual catch) or "negative" (expected catch < actual catch; Supplementary Figure 3) disconfirmation. To determine the relationship between technology use and disconfirmation, we used a logistic regression model where technology was used as a predictor for disconfirmation.

Angler Satisfaction

The effect of technology on overall satisfaction and satisfaction with the number of fish caught was evaluated using linear models with satisfaction as the response and technology use and species type as predictors. Pairwise comparisons of the estimated marginal mean satisfaction between technology and non-technology users for each target species type was used to determine the relationship between technology use and overall satisfaction and satisfaction with the number of fish caught (Lenth et al. 2024).

RESULTS

Over 105 sampling days, we conducted 1,227 angler interviews. Of those, 918 parties completed a pre-trip interview and 696 completed a post-trip interview, for a total of 421 paired (pre- and post-trip) interviews. There were an additional 118 incomplete interviews (anglers chose to discontinue the interview after it began) or declined interviews. Of the interviews conducted, 74% (902 of 1,227) were completed in Dane County (urban), versus 26% (325 of 1,227) in Vilas County (rural). Most interviews were obtained in summer (55%; 675 of 1,227) with the remainder (45%; 552 of 1,227) obtained during winter.

Prevalence of Technology Use among Different Angler Classifications

After removing non-game fish and non-panfish anglers and those interviews where electronic use or target species was not recorded, and interviews with unrealistically high catch rates, the data set for further analysis included 1,049 angler interviews. Of these, 819 were complete for outgoing anglers and 609 were complete for return anglers. Further, 397 of these were paired. Overall, 72% (754) of interviewed parties reported using technology during their fishing trip. Technology use among boat (80%; 352 of 442) and ice (79%; 398 of 505) anglers was similar, while the percentage of technology-using shore anglers (3.9%; 4 of 102) was significantly lower ($P < 0.001$; Figure 3). When both species types were aggregated, boat and ice anglers had statistically similar rates of technology use regardless of target species type, whereas ice anglers targeting game fish (59%; 38 of 64) used technology significantly less often than ice anglers targeting panfish (80%; 255 of 318, $P = 0.033$; Figure 3, Supplementary Table 9).

Predicting Expected and Actual Catch

The most parsimonious model for explaining variation in expected catch included four fixed effects: expected effort, technology use, target species type, fishing mode, and interactions between fishing mode and technology use with species type. This model also included a random intercept by angler (Supplementary Tables 3 and 5). This model explained 34% of the variation in expected catch, where fixed effects explained 25% and random effects explained an additional 9%.

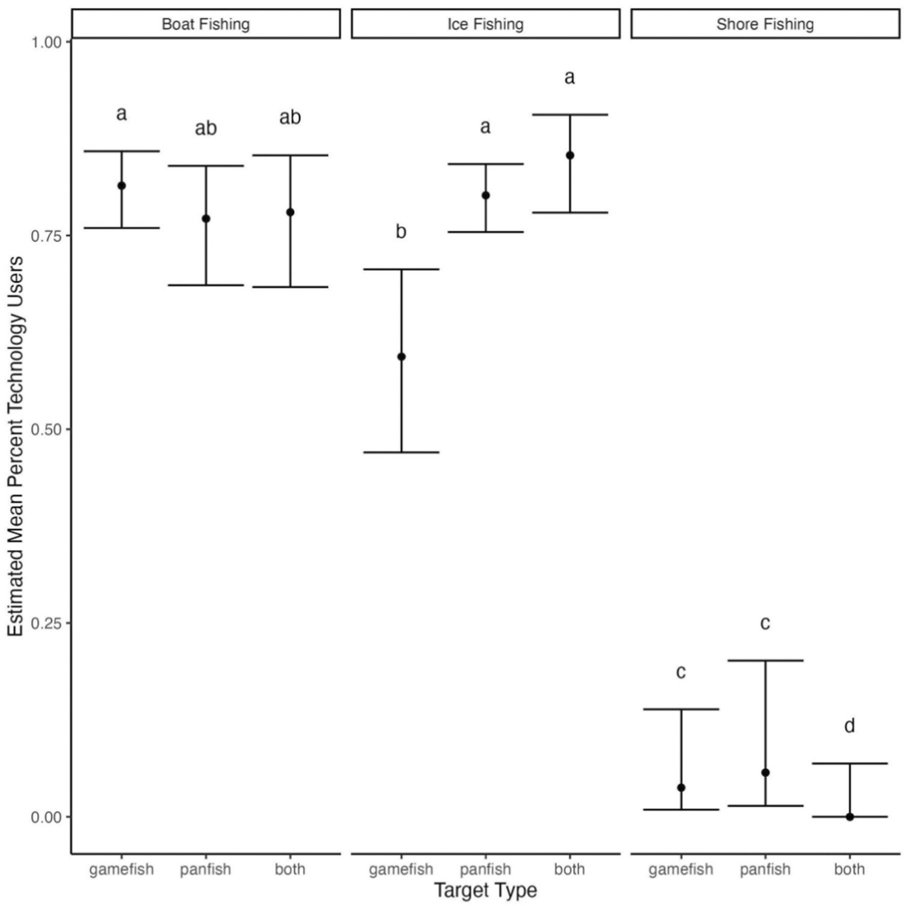

Figure 3. Points indicate the estimated mean percentage of anglers using technology. Error bars represent 95% confidence intervals. Bars with the same letter were found to not to be significantly different in pairwise comparison across fishing modes and target species. Estimated marginal means and their standard errors (SEs) were calculated from the emmeans package apart from the SE for shore-based anglers targeting both game fish and panfish. For this group ($n = 16$), no respondents reported using technology and the SE was calculated from a beta distribution for a set of 16 Bernouli trials with zero "successes."

Table 1. Fixed parameter estimates, standard errors, and *P*-values for the most parsimonious generalized linear mixed effects model for expected trip catch, where expected trip catch is related to species type (game fish/panfish), fishing mode (boat/ice/shore) and technology use (yes/no) and the interaction of fishing mode with species type. Intercept is boat angling gamefish anglers not using technology.

Parameter	Estimate	Standard error	*P*-value
(Intercept)	1.28	0.14	<0.001
scale (expected effort)	0.20	0.04	<0.001
Species type- panfish	1.36	0.15	<0.001
Fishing mode- ice	−0.91	0.12	<0.001
Fishing mode- shore	−0.56	0.17	<0.001
Technology use	0.35	0.12	0.003
Species type- panfish: fishing mode- ice	0.63	0.15	<0.001
Species type-panfish: fishing mode- shore	0.03	0.24	0.890
Species type- panfish: technology use	−0.32	0.16	0.040

The estimated marginal mean expected effort across all trips was 7.35 (SE = 2.69) angler-hours per party. Panfish anglers expected to catch significantly more fish than game fish anglers ($P < 0.001$; Table 1; Figure 4; Supplementary Table 10). Among anglers targeting game fish, boat anglers expected to catch more than either ice or shore anglers ($P < 0.001$), and the use of technology significantly increased expected catch across game fish anglers ($P = 0.003$). Technology use had no effect on expectations of panfish anglers (significant negative species–technology interaction; $P = 0.04$; Table 1; Figure 4; Supplementary Table 10).

There were two models within two AIC for explaining actual catch (Supplementary Table 6); however, given that their explanatory power was equivalent, we chose to interpret only the most parsimonious model, which included fixed effects of effort, species type, fishing mode, species type fishing mode interaction, and a random intercept for angler (Supplementary Tables 4 and 6). This model explained 30% of the variation in actual catch, which was evenly divided between the fixed effects and variation among anglers (random effect). In contrast to the model for expected catch above, technology was not included in the most parsimonious model for explaining actual catch. (Supplementary Tables 4 and 6).

The estimated marginal mean trip effort was 8.66 angler-hours per party (SE = 2.75). Anglers targeting panfish had a higher actual catch compared to game fish anglers ($P < 0.001$), but their catch did not vary with angling mode (Table 2; Figure 5; Supplementary Table 11). Catch did vary with angling mode among game fish anglers. Anglers targeting game fish via boat caught more fish than ice or shore anglers ($P < 0.003$; Table 2; Figure 5; Supplementary Table 11).

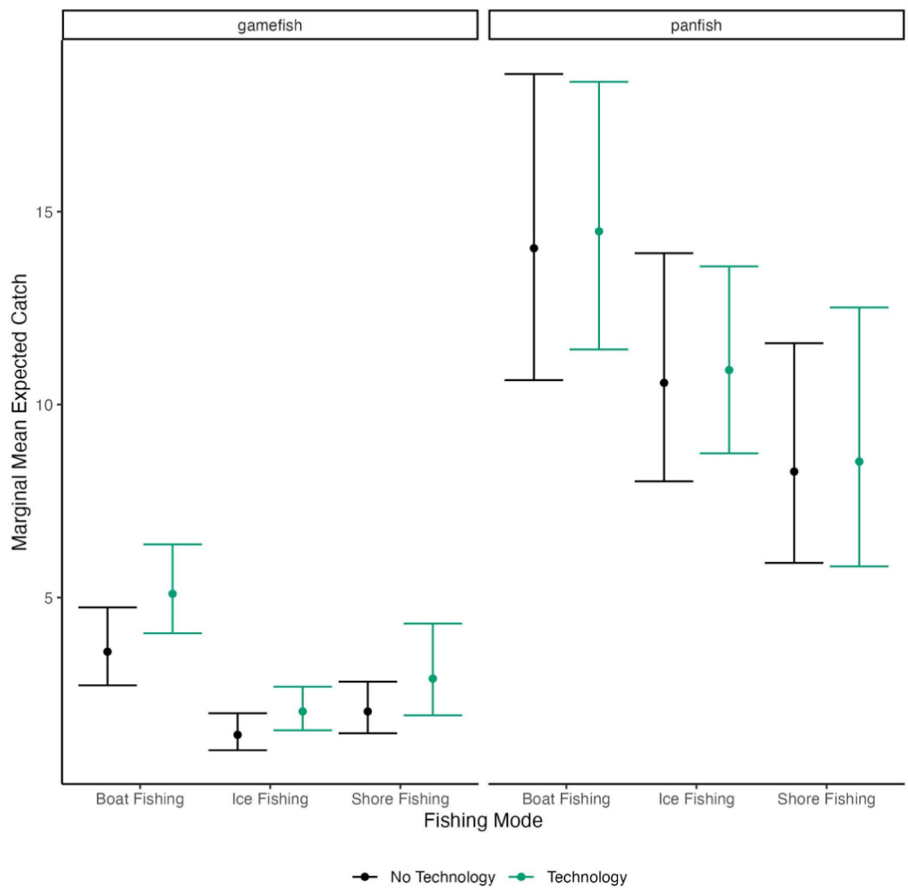

Figure 4. Points indicate estimated marginal means at mean expected trip length (7.35 angler-hours) from hierarchical generalized linear mixed effects model of expected catch as a function of expected effort, species type (panfish or game fish), fishing mode (ice, shore, or boat), and technology use (yes- green/no- black). Bars indicate 95% confidence interval.

Table 2. Fixed parameter estimates, standard errors, and *P*-values for the most parsimonious generalized linear mixed effects models determined by Akaike information criterion, where trip catch is related to species type (game fish/panfish), fishing mode (boat/ice/shore), and their interaction. Intercept is game fish anglers fishing from boats.

Parameter	Estimate	Standard error	*P*-value
(Intercept)	0.73	0.11	<0.001
scale(total effort)	0.36	0.06	<0.001
Species type- panfish	1.15	0.15	<0.001
Fishing mode- ice	−0.91	0.21	<0.001
Fishing mode- shore	−1.14	0.36	0.002
Species type- panfish: fishing mode- ice	0.88	0.24	<0.001
Species type- panfish: fishing mode- shore	0.70	0.42	0.100

Relationship Between Actual and Expected Catch

The most parsimonious model explaining the relationship between expected and actual catch included actual catch as the response and expected catch, species type (game fish/panfish), technology use and the interaction of species type and technology use as fixed predictors with a random intercept of angler nested within lake (Supplementary Tables 7 and 8). Most anglers failed to meet their expectations of catch, as the effect of expected catch on actual catch was far less than 1 (0.27 ± 0.04; Figure 6; Table 3). As in the model for actual catch above, panfish anglers caught more fish than game fish anglers ($P < 0.001$). While technology use was included in the model, neither the direct effect of technology nor its interaction with species type was significant ($P > 0.3$; Table 3; Figure 6). Supporting this, technology was not a significant predictor of catch disconfirmation (i.e., whether anglers caught more or fewer fish than expected) when tested directly with logistic regression ($P = 0.21$; Table 4; Supplementary Figure 3).

Angler Satisfaction

Mean overall satisfaction differed marginally between panfish anglers using technology and those that did not ($P = 0.04$); anglers using technology had slightly lower overall satisfaction (Supplementary Table 12). Game fish anglers using technology reported significantly lower overall satisfaction than game fish anglers not using technology ($P < 0.001$; Supplementary Table 12). In contrast, no significant differences in catch satisfaction were found between technology users and non-users for both panfish ($P = 0.06$) and game fish ($P = 0.53$) anglers (Figure 7; Supplementary Table 12).

The same statistical analyses were conducted using a broader definition of technology, which included GPS, underwater cameras, and trolling motors in addition to sonar equipment, and the results did not differ from the results above, which define technology by the use of sonar equipment such

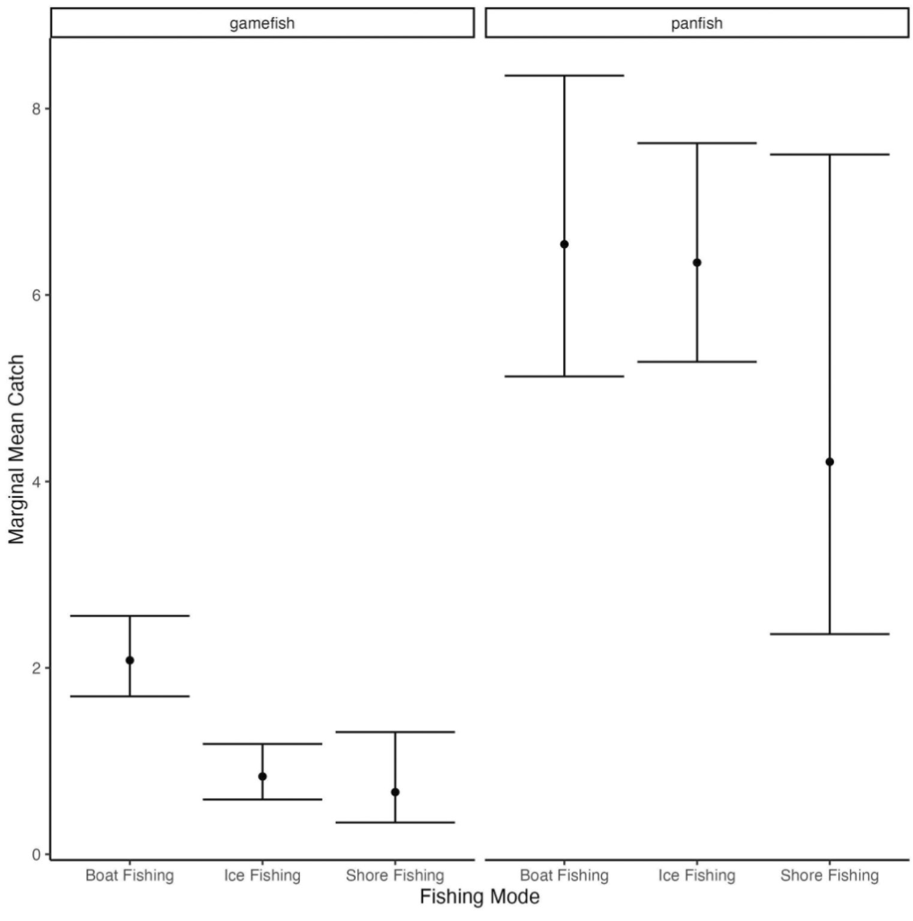

Figure 5. Points indicate estimated marginal mean catch at the average trip length (8.66 angler-hours) from hierarchical generalized linear mixed effects model of trip catch as a function of angler effort, species type (panfish or game fish), and fishing mode (ice, shore, or boat). Bars indicate 95% confidence interval.

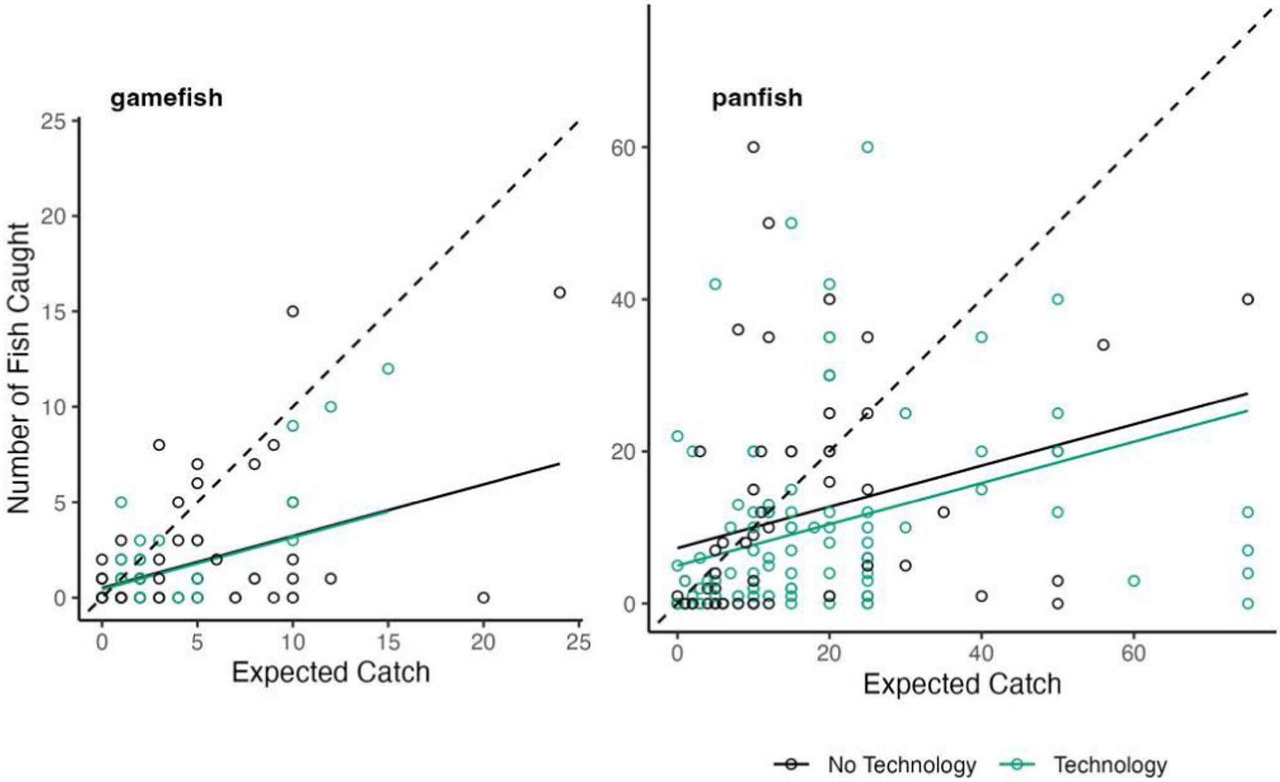

Figure 6. Paired pre- and post-trip angler interviews. Lines (green/black) are predicted values from the generalized linear mixed effects model where actual catch was the response to expected catch, species type (game fish/panfish), technology use (yes/no) and their interaction of species type and technology use with a random intercept of angler nested within lake. Points indicate observations of technology-using anglers (green) and non-using anglers (black). The dashed demonstrates a 1:1 relationship between expected and actual trip catch.

Table 3. Parameter estimates, standard error, and *P*-values for a generalized linear model where trip catch was the response variable, and expected trip catch, species type (game fish/panfish), technology use (yes/no) and their interaction were the predictors.

Parameter	Estimate	Standard error	*P*-value
(Intercept)	0.51	1.42	0.720
Expected catch	0.27	0.04	<0.001
Technology use	−0.07	1.80	0.970
Species type - panfish	6.77	1.76	<0.001
Technology use: species type - panfish	−2.22	2.26	0.330

Table 4. Parameter estimates, standard error, and *P*-values for a binomial generalized linear model where the log odds of positive disconfirmation (i.e. actual catch was higher than expected catch) was the response variable, and technology use was the predictor.

Parameter	Estimate	Standard error	*P*-value
(Intercept)	−1.32	0.21	<0.0001
Technology use	−0.37	0.29	0.2100

as depth finders, down/side-scan equipment and front facing sonar equipment. (Supplementary Tables 13–19).

DISCUSSION

There are increasing concerns about the effects advancements in technology may be having on recreational fisheries (Cooke et al. 2021). We found that technology use was widespread among both game fish and panfish anglers in Wisconsin, and commonly used by boat and ice anglers, although rarely used by shore anglers. Our results indicated that technology slightly increased expected catch for game fish anglers, but not panfish anglers, and had no effect on actual catch for anglers targeting either species type (i.e., technology was not included in the most parsimonious model). Technology use also had no effect on disconfirmation (i.e., it did not help anglers meet or exceed expectations), and very few anglers overall experienced positive disconfirmation. Technology use did, however, reduce angler satisfaction with their trips. Technology-using panfish and game fish anglers both reported lower satisfaction with their trip overall.

Prevalence of Technology Use among Different Angler Classifications

Rates of technology use by boat and ice anglers in our study (80% and 79%, respectively) aligned with a previous Wisconsin ice angler study (70%; Feiner et al. 2020a). Shore anglers used technology less than ice and boat anglers, likely because these technological tools are difficult to use when fishing from shore. Across fishing modes we found anglers targeting game fish on the ice used technology less than anglers targeting panfish or both, which is consistent with Feiner et al. (2020a). Future research could be more effective if focused on technology use at the species level, particularly in systems where trip effort is often allocated to multiple species.

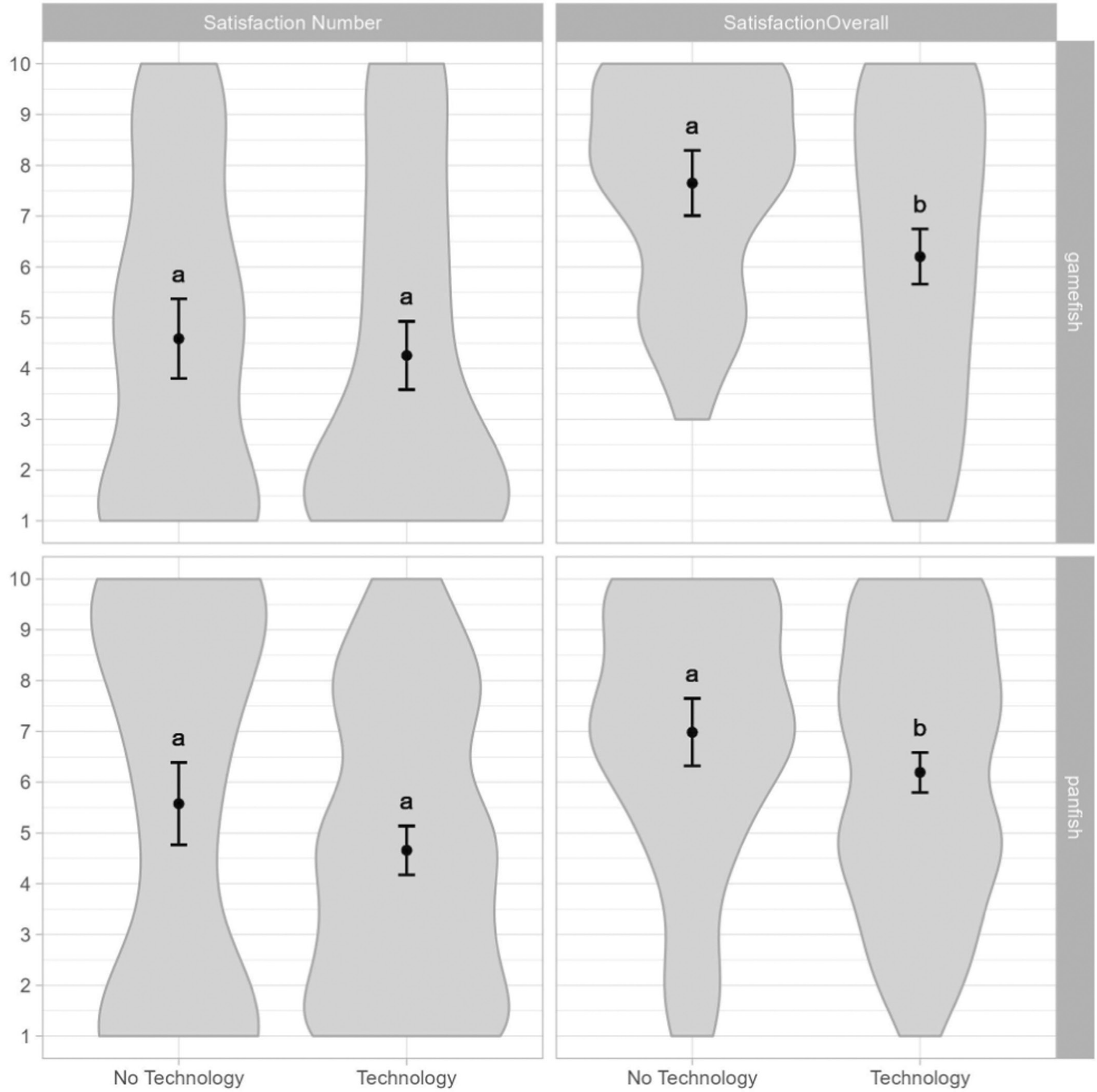

Figure 7. Distribution of satisfaction with number of fish caught and satisfaction overall ratings on a scale from 1 to 10 with relationship to difference between expected and actual catch. Error bars represent the 95% confidence interval for estimated marginal mean satisfaction. Points indicate estimated marginal mean satisfaction. Bars with the same letter were found to not to be significantly different in pairwise comparison within species type.

Predicting Expected and Actual Catch

Expectations of Catch

Variation in catch among individual anglers explained a considerable amount (~9%, about one-third of the total explanatory power of the model) of variation in angler catch expectations. This finding is consistent with several previous studies that have demonstrated the importance of heterogeneity among recreational anglers on preferences and expectations (Arlinghaus 2006; Beardmore et al. 2011, 2013; Hunt et al. 2019). For instance, previous studies have examined the effects of angler skill or avidity on catch or satisfaction (Beardmore et al. 2015; Birdsong et al. 2021; Gundelund et al. 2022). However, this study did not include a metric for avidity. Accounting for avidity by making comparisons at the trip level and including angler random effects resulted in substantial explanatory power, from one-third to one-half of all variation explained.

Technology also slightly, but significantly, increased expected catch among game fish anglers, but not panfish anglers. As discussed above, expectations may be influenced by previous experience and knowledge, and similarities in expectations among different anglers may be derived from angler information sharing. For example, recent studies of Wisconsin anglers found that 83% (344 of 413) report telling friends and family about their most recent fishing experiences (C. Iwicki and coauthors, Rutgers University, personal communication).

Thus, while individual anglers vary in their skill and outlook (i.e., optimistic/realistic), information sharing could homogenize angler expectations. This effect would lessen the impacts of individual differences in factors like technology use, particularly when the use of technology is as widespread as it was in this study.

Comparing anglers targeting different sets of species types, panfish anglers expected more than double the number of fish per angler hour as game fish anglers, which can be readily explained by the higher abundance of panfish species compared to game fish as well as generally higher average catch rates (Feiner et al. 2022). Boat anglers averaged the highest expected catch, while ice and shore anglers had the lowest expected catch for game fish and panfish anglers, respectively. Expectation of catch may be higher because catch rates tend to be higher during open water fishing seasons than ice fishing seasons in northern Wisconsin (Sass et al. 2023).

Actual Trip Catch

Previous studies investigating the effects of technology on catch rates have been varied. Feiner et al. (2020a) observed two to three times higher catch rates among panfish anglers who used technology compared to non-technology users in the Wisconsin ice fishery, but little effect among game fish anglers. In contrast, Neely et al. (2022, 2023) used experimental angling to find no effect of technology (live-imaging sonar) on open water crappie *Pomoxis* spp. or Blue Catfish *Ictalurus furcatus* catch. In support of Neely et al. (2022), but in contrast to Feiner et al. (2020a) and Neely et al. (2023), we found that technology use did not influence trip catch. These results may suggest that current concerns about technology causing widespread overharvest in recreational fisheries have yet to materialize. We acknowledge that additional work evaluating the complex relationships between angler avidity, specialization, previous experiences, and catch could better inform the true effects of technology and provide options for managing recreational fisheries in the face of technological advancements.

Comparison of Actual and Expected Catch

We found that most anglers did not meet their catch expectations, and that technology use had no effect on the disparity between expected and realized catch across angler types. Expectation setting among anglers is relatively understudied, but previous research has found that anglers tend to rate their skills highly and, therefore, may expect higher catch rates. For example, when given an opportunity, a majority of anglers (>75%) classified themselves as “very” or “most specialized” (Salz and Loomis 2005). However, an angler’s self-perceived skill, and therefore expectation, may have little actual relationship with catch, as we observed here. Other studies have found that angler catch rates are not significantly different from a random distribution (Seekell 2011), which suggests that the differences between expectations of catch and actual catch may be partially derived from inaccurate perceptions of skill and ability to catch fish. However, the disconnect between expectations and reality may be exacerbated by technology use, which may inflate the expectation of catch while actual catch remains the same (Neely et al. 2023).

Angler Satisfaction

Technology use was associated with lower overall trip satisfaction for panfish and game fish anglers. Technology may be directly impacting angler satisfaction as technology gives anglers a sense of missed catch opportunities. That is, technology enables anglers to detect fish, which means they are more aware of fish that may not bite. The effect of this may vary by an angler’s motivation, which have been shown to derive from many factors (i.e., number of fish, species types, size of fish, etc.; Beardmore et al. 2011; Birdsong et al. 2021; Gundelund et al. 2022). This disconfirmation demonstrates the need to further understand how the relationship between expectations and actual trips relate to satisfaction in recreational fisheries. Neely et al. (2023) suggested that anglers using technology may spend more time searching for “optimum” fishing spots rather than actively fishing, which may lower overall satisfaction. Additionally, Neely et al. (2023) found that anglers not using a Livescope (forward-facing sonar) believed using a Livescope would have increased their catch, while Livescope-using anglers did not believe the technology increased their catch. Coupling the results of Neely et al. 2023 and the results presented here suggests that live-image technologies may increase angler expectations, but not necessarily actual catches; however, these expectations are not being realized, directly impacting angler satisfaction.

Other recreational angling studies have found that the drivers of satisfaction vary widely among anglers, from interests in catching fish (Arlinghaus 2006) to non-catch-related factors (Fedler and Ditton 1994). This is particularly true for anglers who are motivated by non-catch metrics, as they are better able to control for their preferred fishing trip (i.e., calm weather or proximity to home; Arlinghaus 2006; Beardmore et al. 2011), which are difficult to control for resource managers. However, anglers who rated low catch satisfaction had much more variability in their overall satisfaction than anglers who had higher catch satisfaction (i.e., anglers with low catch satisfaction may still indicate high overall satisfaction). This corroborates other studies’ findings, which indicate that while catch is not the only determinant of satisfaction, anglers are more satisfied when they catch more fish (Arlinghaus 2006; Beardmore et al. 2015).

CONCLUSION

Complex social–ecological systems may require treating behavioral change in human populations with the same level of urgency as we treat population changes at any other level of a natural system, and the widespread adoption of fishing technology is no different. This study represents one of a very small number of investigations into the impacts of technology use by recreational anglers and one of the first to examine the impacts of technology use not only on catch but also on expected catch and trip satisfaction. The role of recreational angling technologies was complex; we showed variable effects of technology on angler expectations but no effects on actual catch. Given that technology use did not affect catch, fears of overharvest by technology-using anglers may be unfounded, and significant management actions (e.g., catch or technology restrictions) may not be necessary. The greater cause for concern may be the mismatch between angler expectations and actual trip catch, which was shown to decrease catch satisfaction for some anglers. For resource managers, angler satisfaction (and the factors that govern it) may be critical for the sustainable management of recreational fisheries. Further research aimed at understanding the formation of angler expectations could offer important insights into multiple facets of recreational angler behavior and new tools for the management of fisheries as social–ecological systems.

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SUPPORTING INFORMATION

Additional supplemental material may be found online in the Supporting Information section at the end of the article.

Data S1. AFS